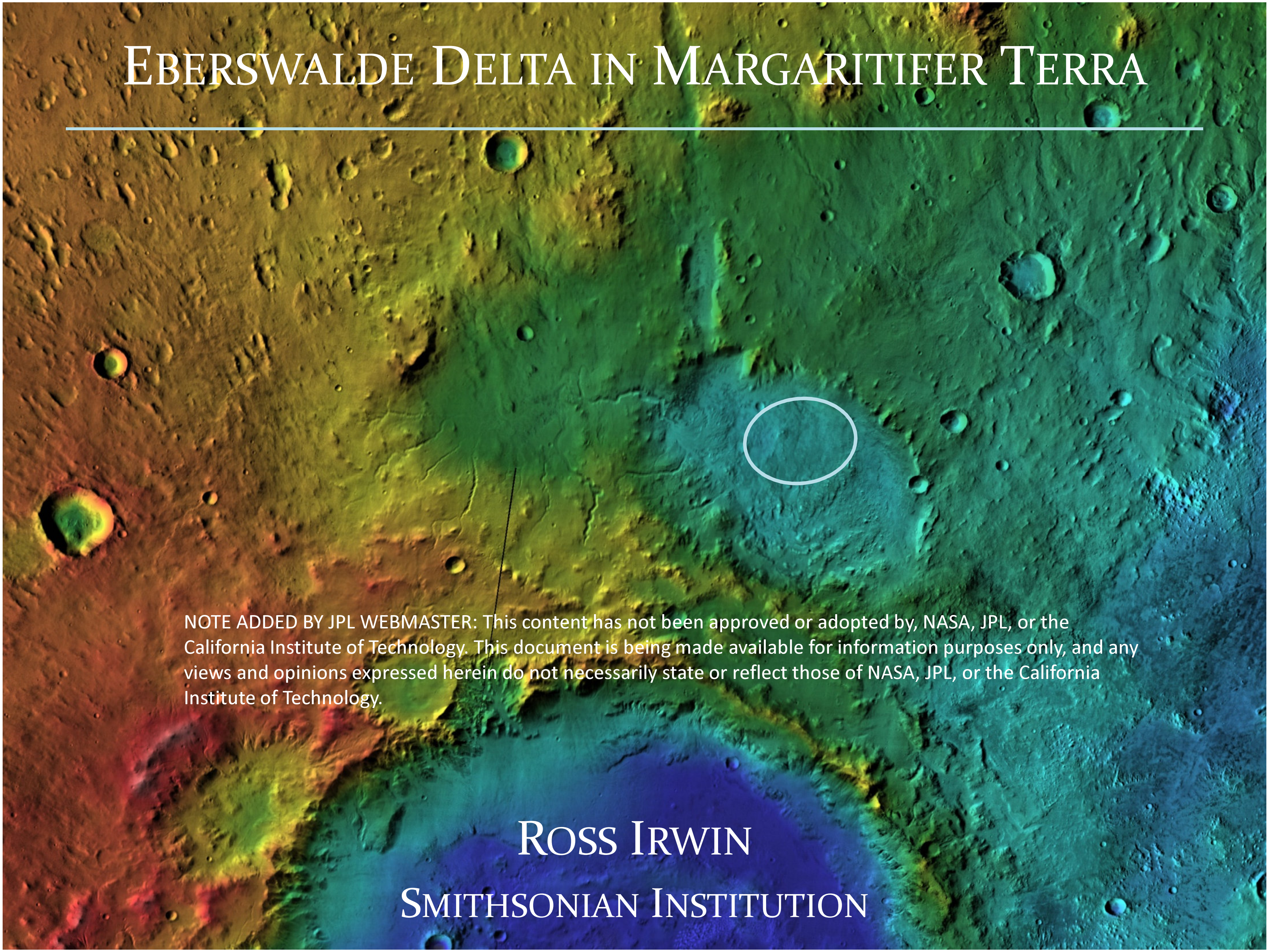


Eberswalde Delta in Margaritifer Terra

Ross Irwin

Smithsonian Institution

The first car at the bottom of the world.

The Australian National Research Expedition really had no choice.

They wanted a car that "any member of the party could hop into and drive off without a moment's hesitation."

And the Volkswagen just happens to fill the bill.

The big trick is the VW's air-cooled rear engine. It has no radiator. It uses no water or antifreeze. It just goes.

(Antarctica #1 stood for days at 50° below zero and started without a tremble.)

The rear engine gave the VW so much extra traction it climbed "straight up and down the slopes." (But they cheated a little; sometimes they used chains.)

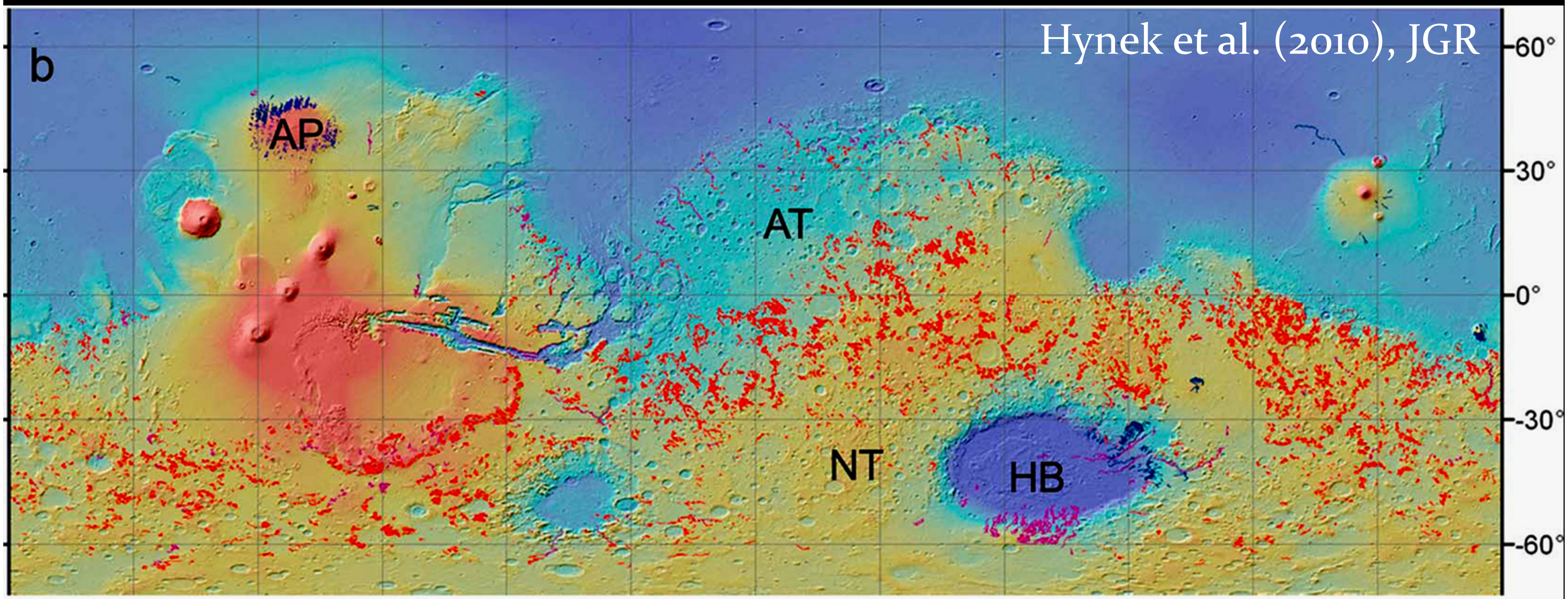
Another reason the Volkswagen went where even the dogs wouldn't go is its sealed bottom.

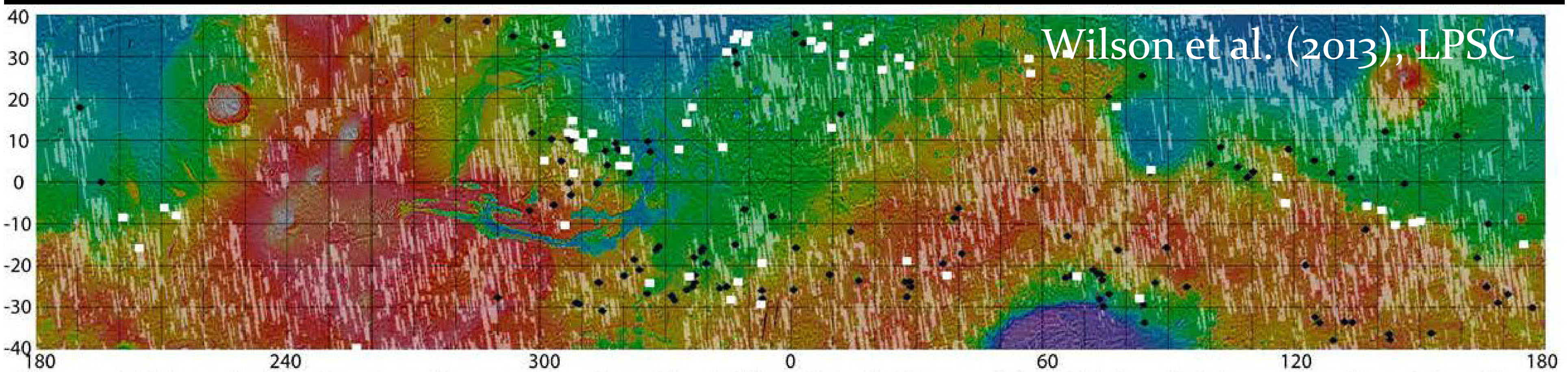
It took an awful beating, but that's what it's there for. To protect the works inside against the weather outside.

Things got so fierce that one man said, "Now we know what it'll be like when Hell freezes over."

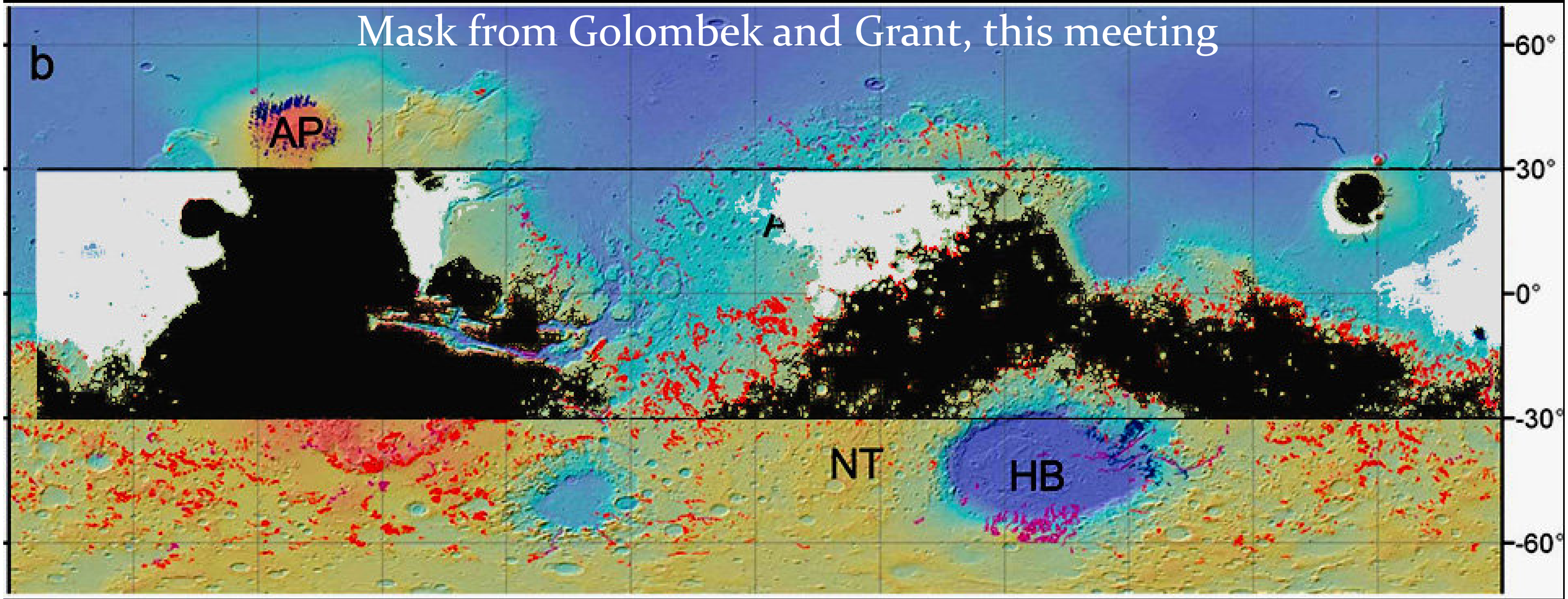
So if it ever does, you know what car to buy.

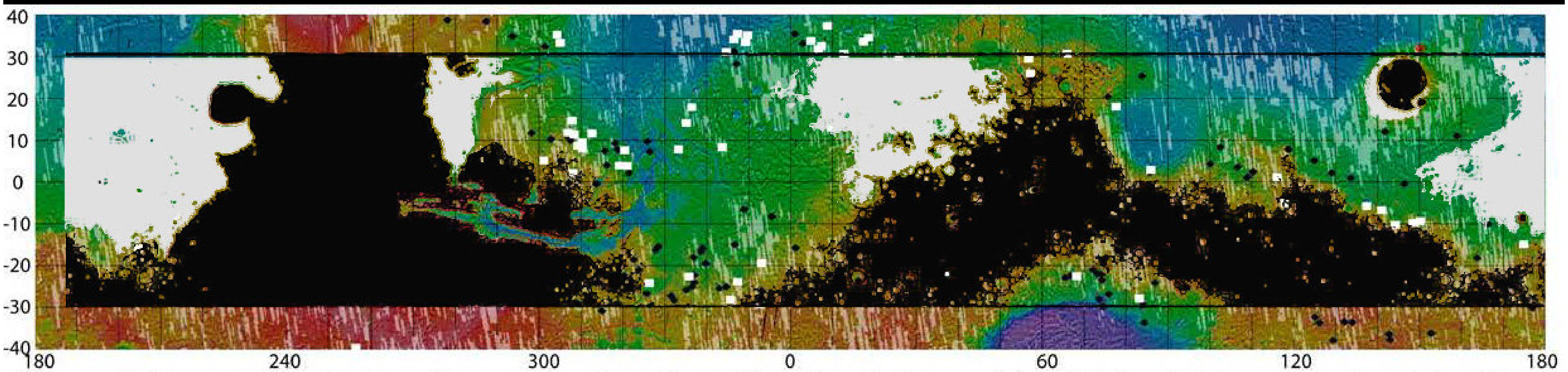
Valley Networks and Prominent Deposits

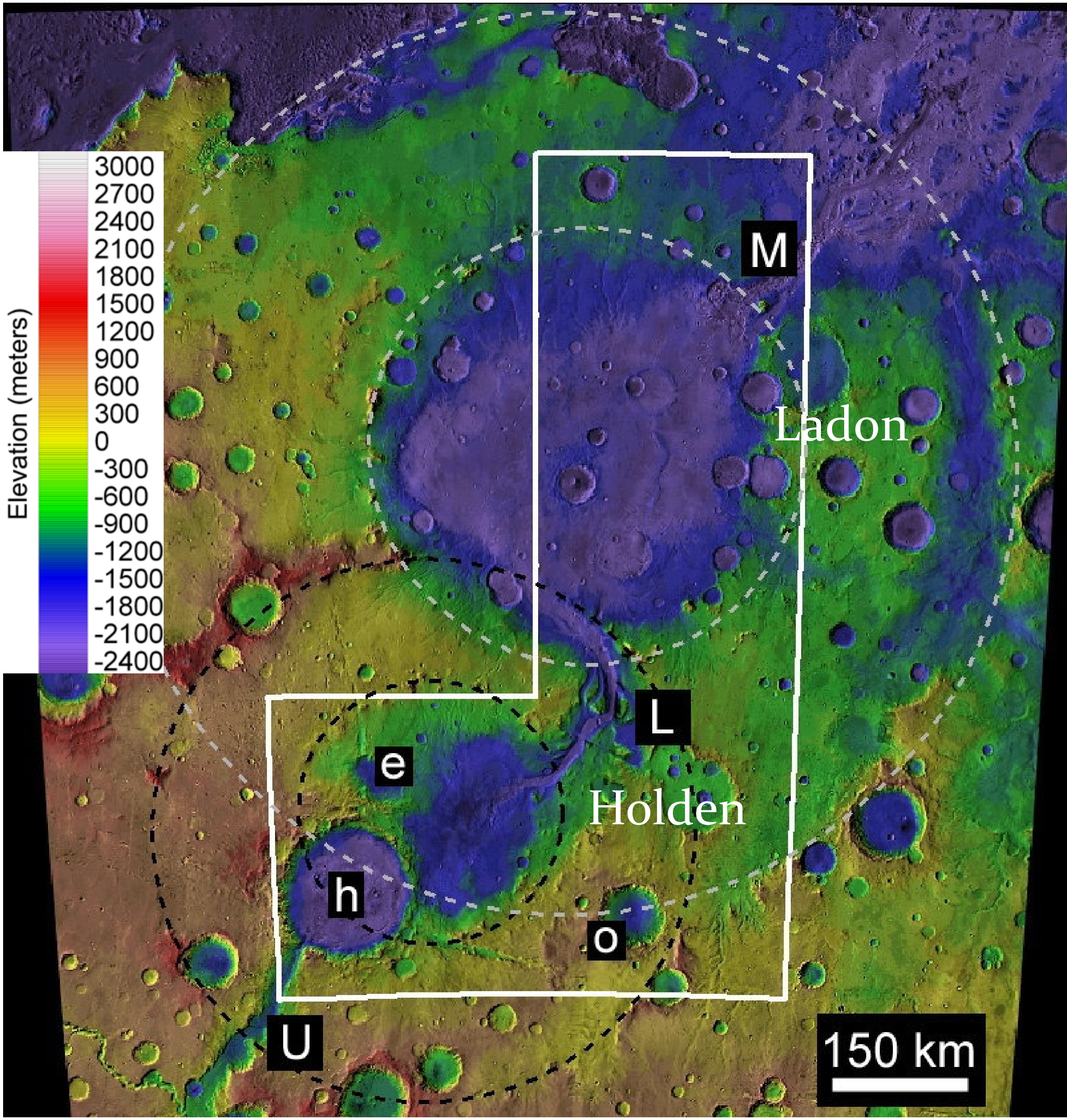




VALLEY NETWORKS AND PROMINENT DEPOSITS







REGIONAL CONTEXT

U: Uzboi Vallis

L: Ladon Valles

M: Morava Valles

h: Holden crater

e: Eberswalde crater

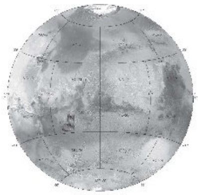
o: Ostrov crater

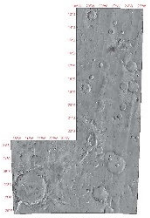
Ladon and Holden impact basin rings are dashed

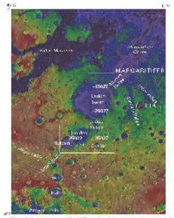
U.S. Department of the Interior
U.S. Geological Survey

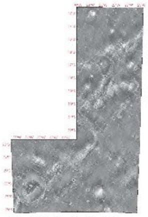
Prepared for the
National Aeronautics and Space Administration

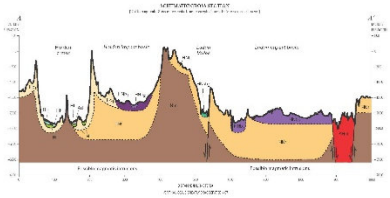
Scientific Investigations Map 3209

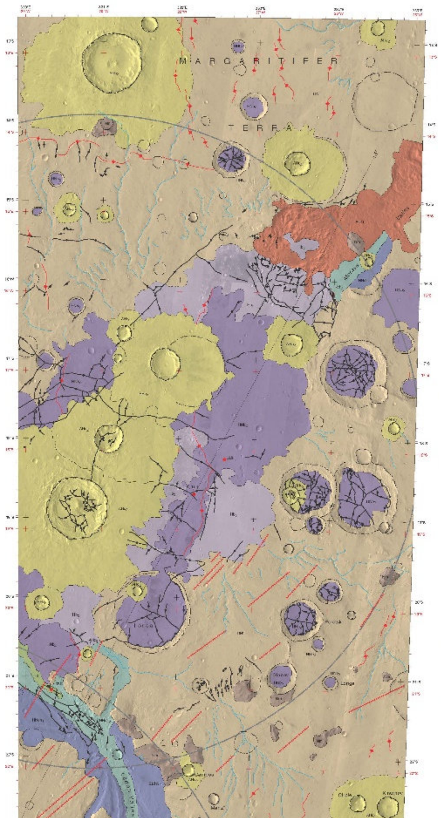


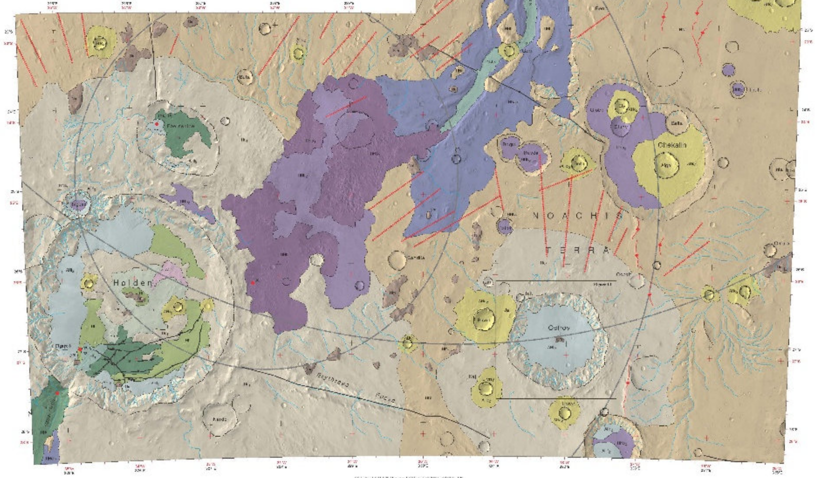




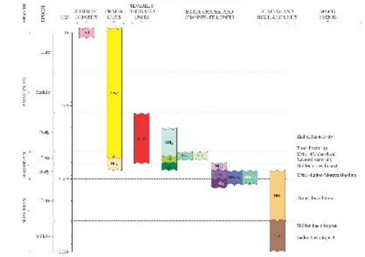








CORRELATION OF MAP UNITS

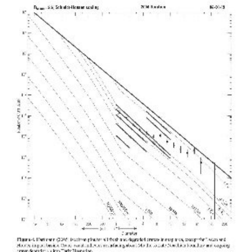


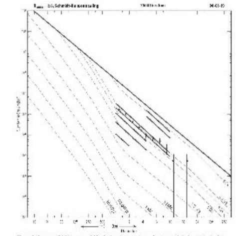
DESCRIPTION OF MAP UNITS

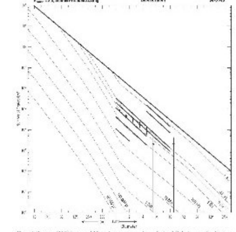
SURFICIAL DEPOSITS

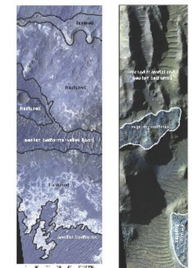
CRATER UNITS

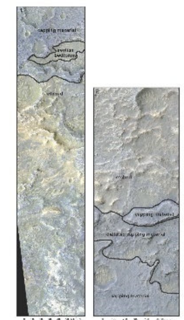
SEVERELY DEFORMED UNITS

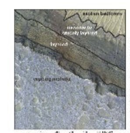


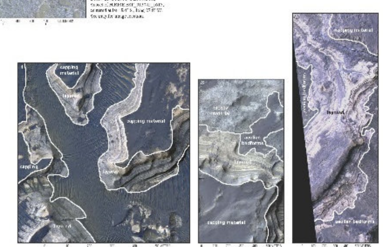


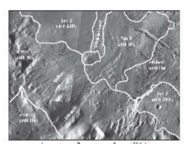


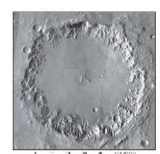












Geologic Map of the MTM –15027, –20027, –25027, and –25032 Quadrangles, Margaritifer Terra Region of Mars

By
Rossman P. Irwin, III[1], and John A. Grant[1]

2013

ULM System Downstream

N: Nirgal Vallis

U: Uzboi Vallis

L: Ladon Valles

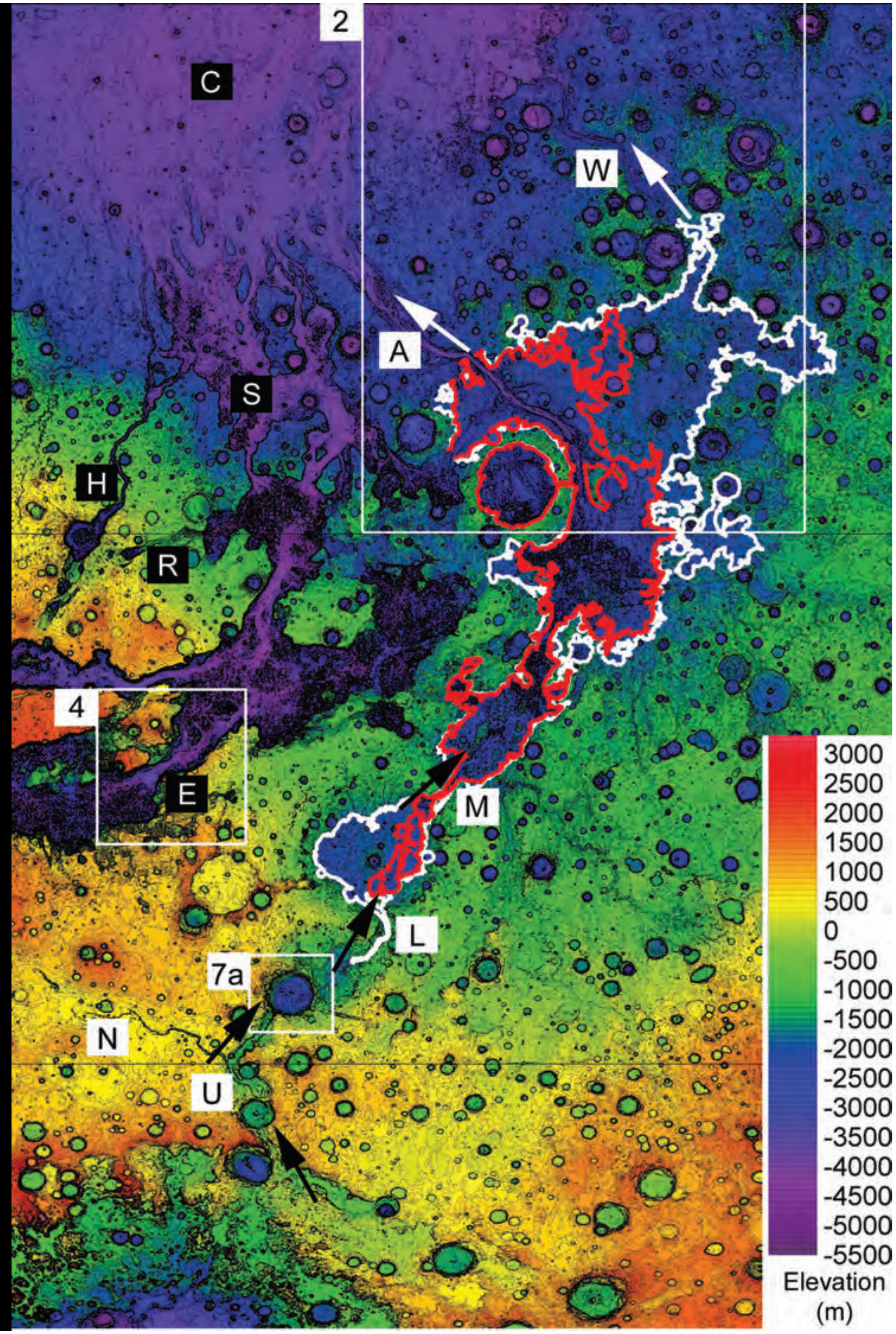
M: Morava Valles

A: Ares Vallis

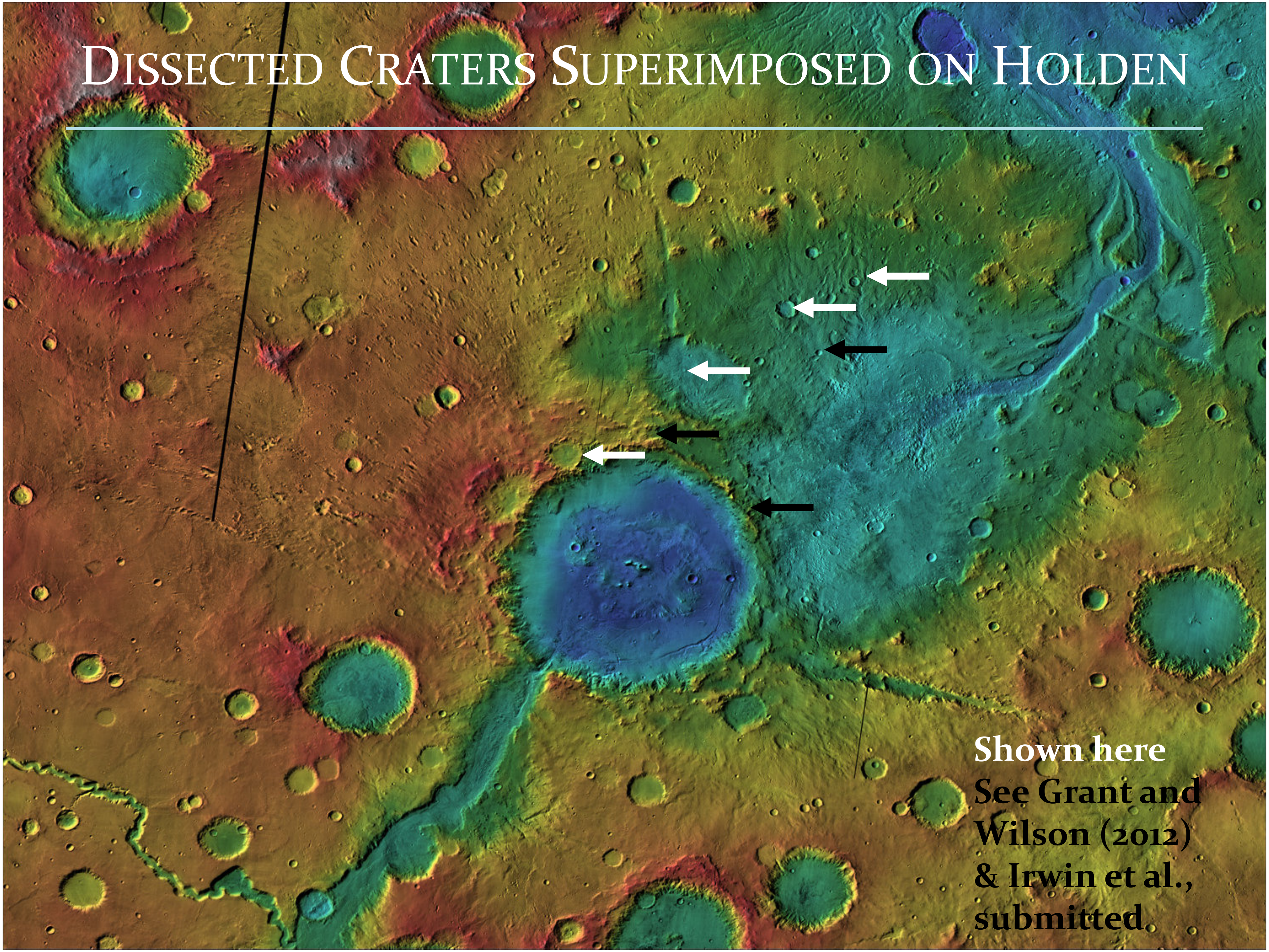
W: Mawrth Vallis

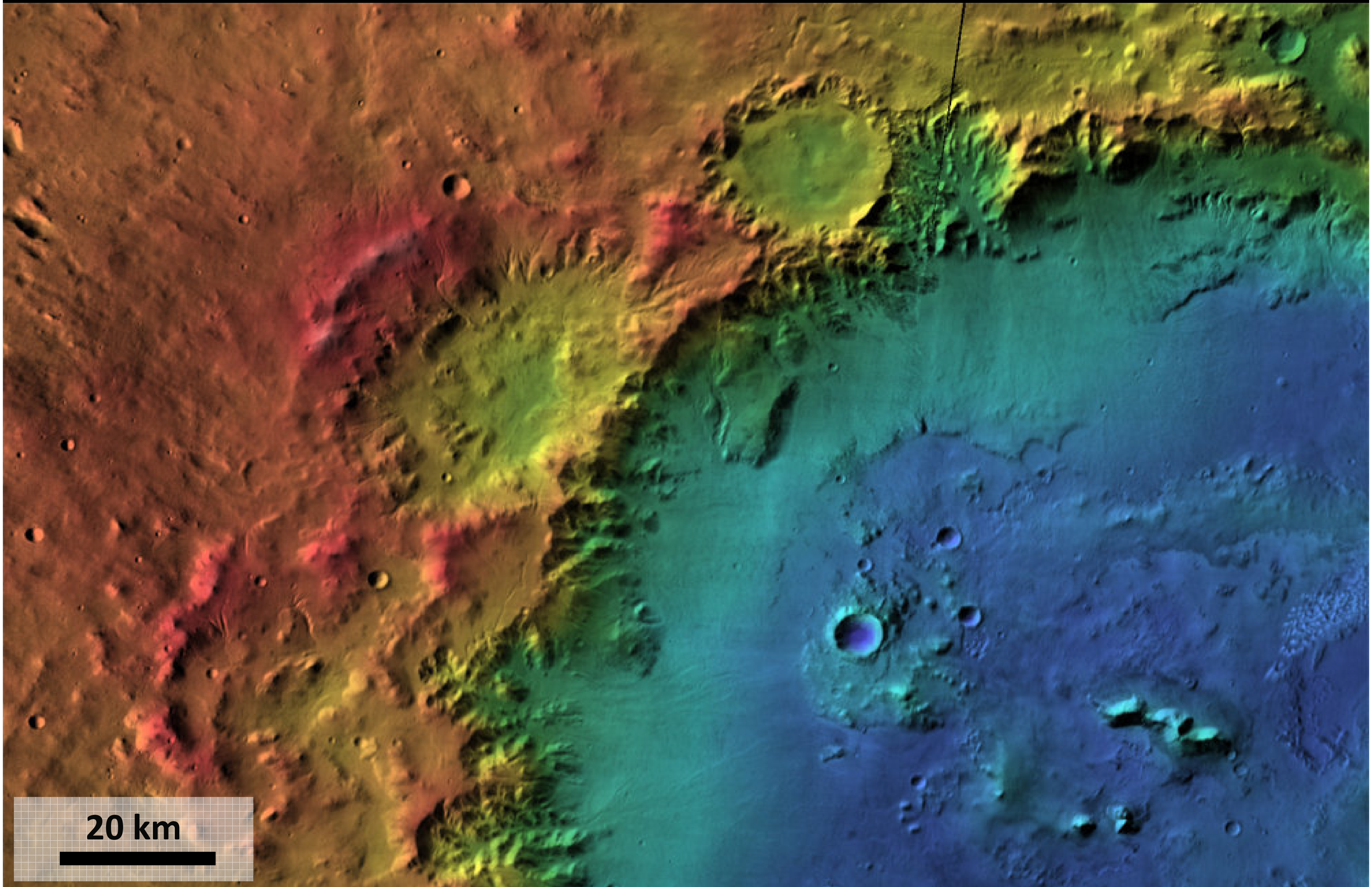
White: -1880 m. Red: -2000 m

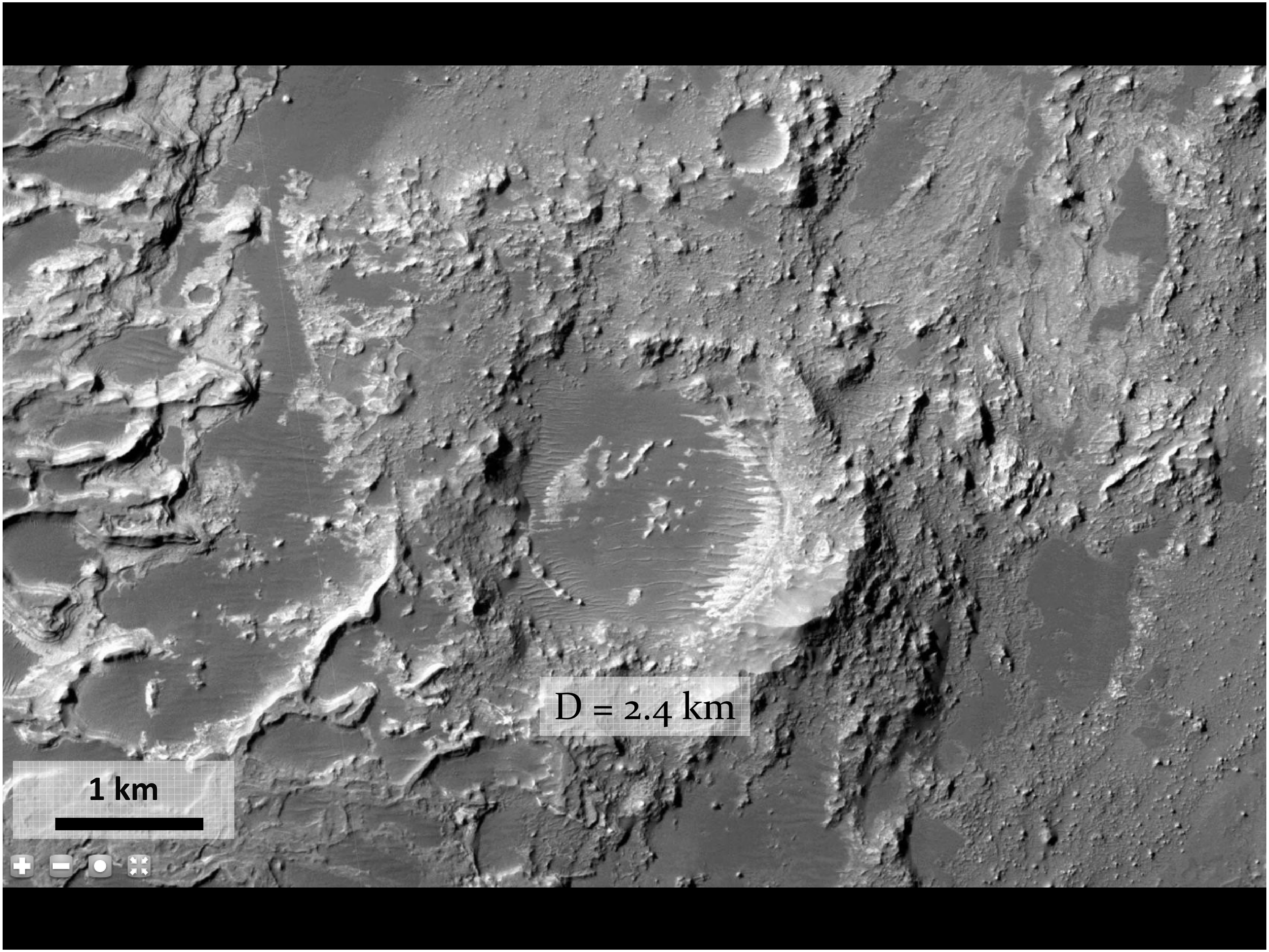
Irwin and Grant (2009) in
Burr et al. (2009) eds.,
Megaflooding on Earth and Mars

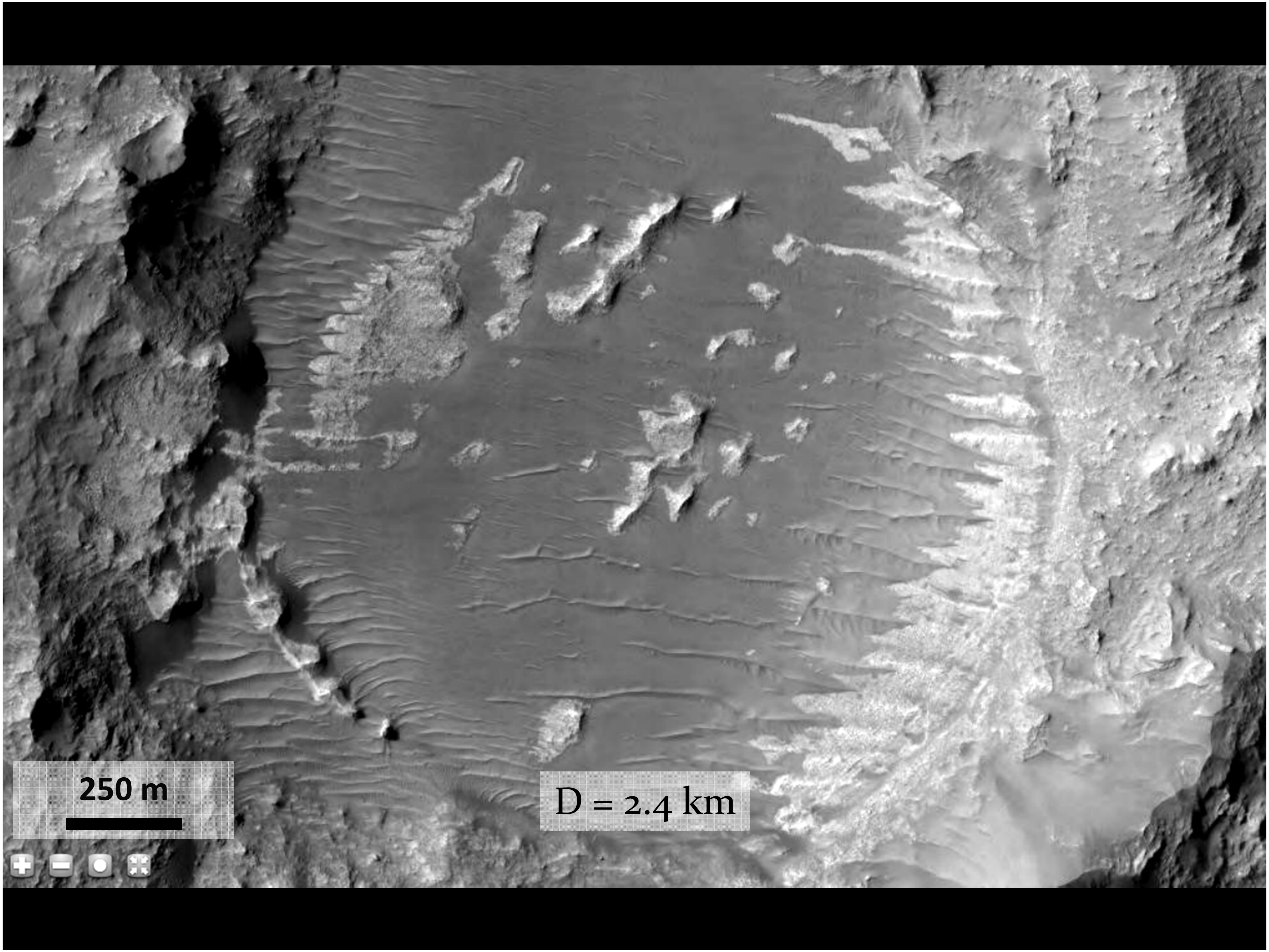


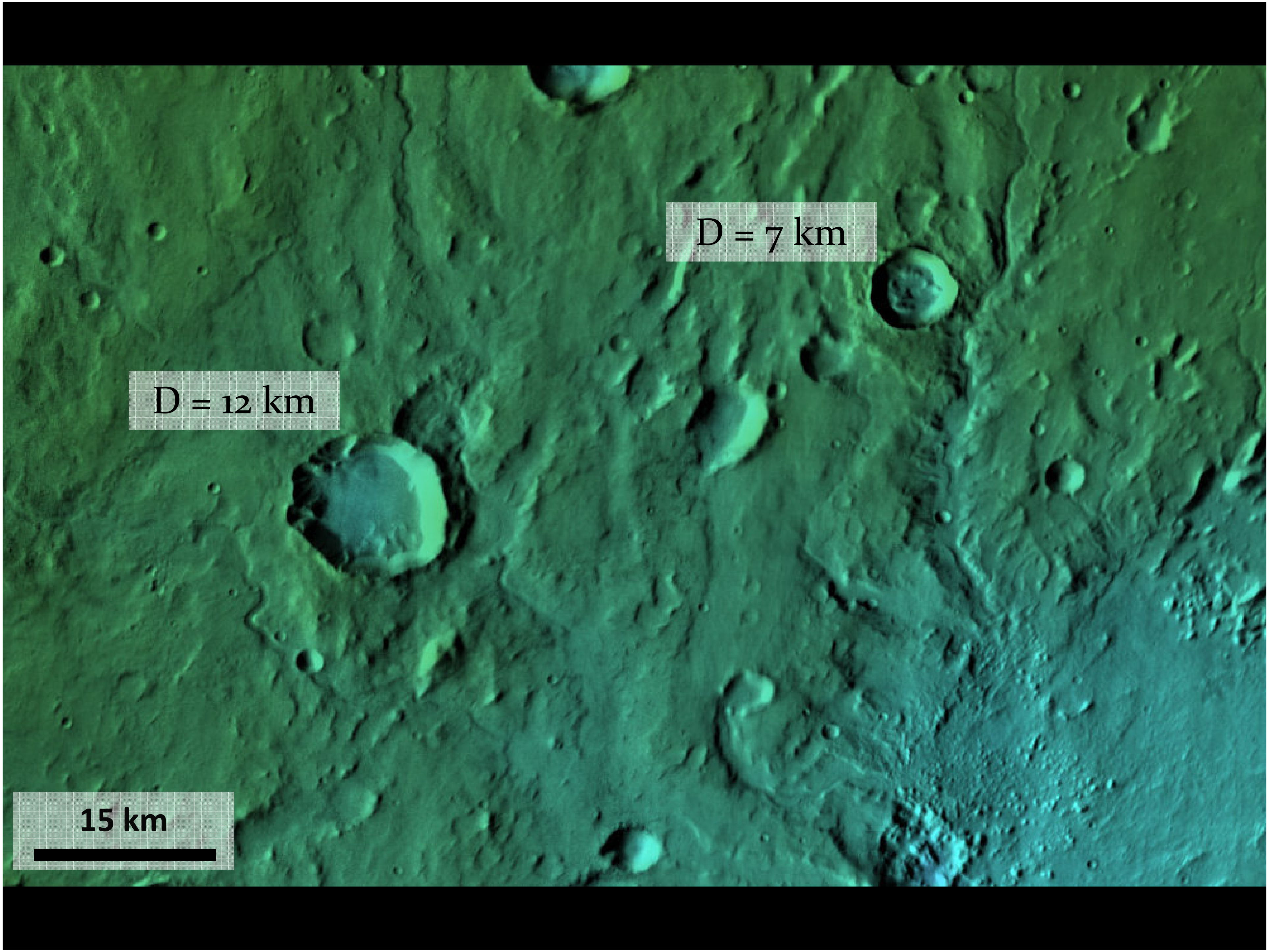
Dissected Craters Superimposed on Holden

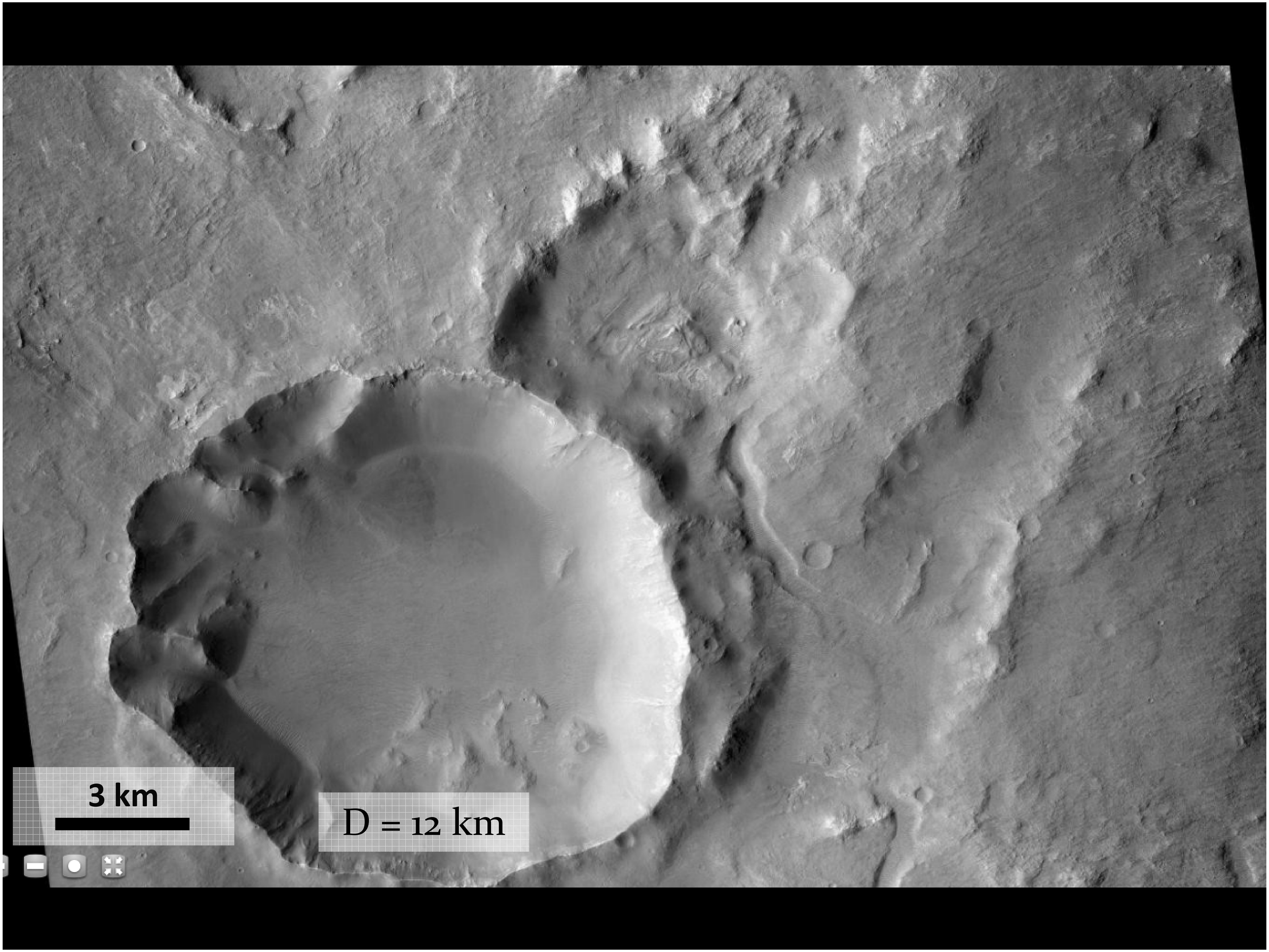



20 km

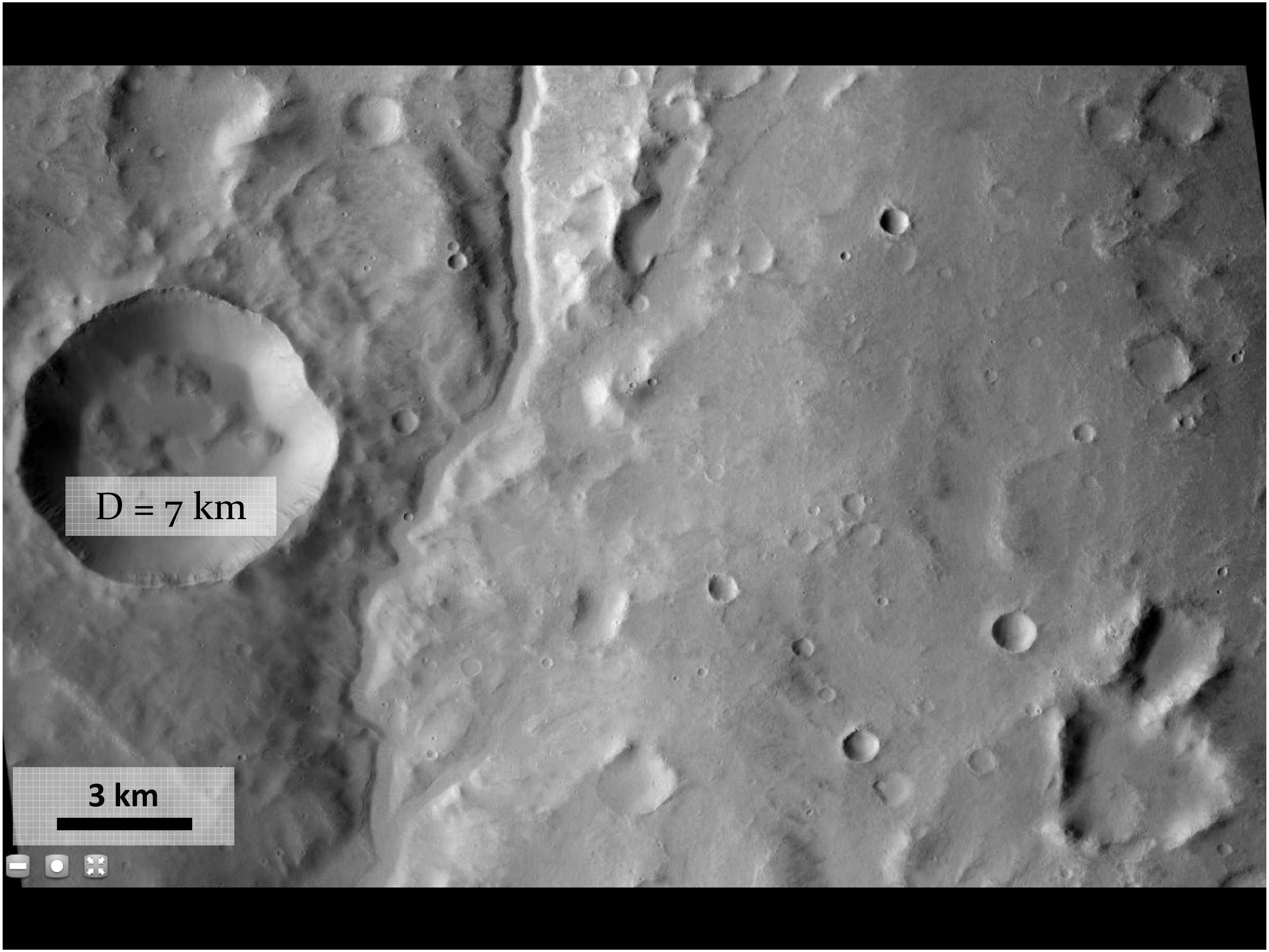

D = 2.4 km
1 km


250 m
D = 2.4 km

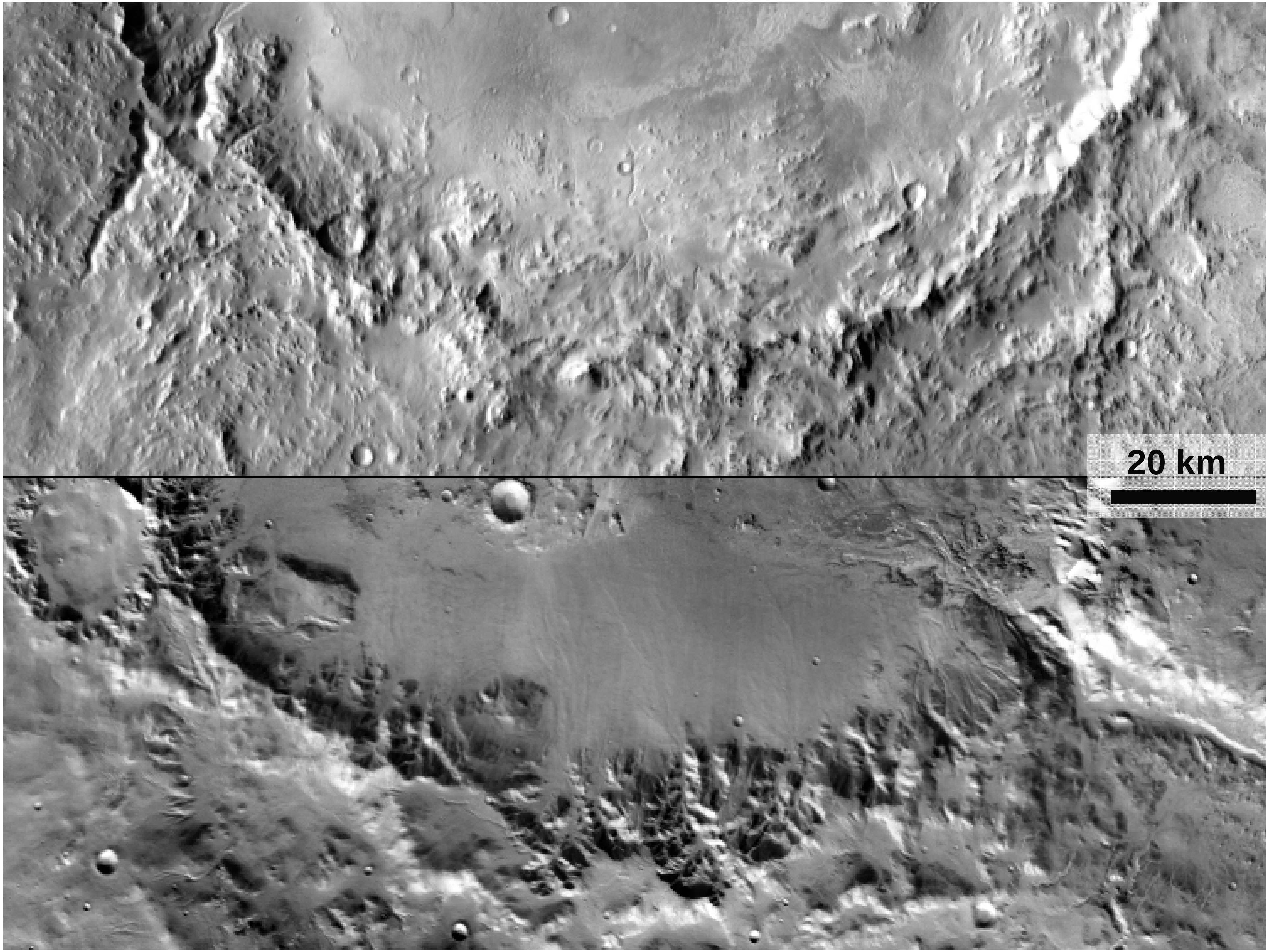

D = 7 km
D = 12 km
15 km

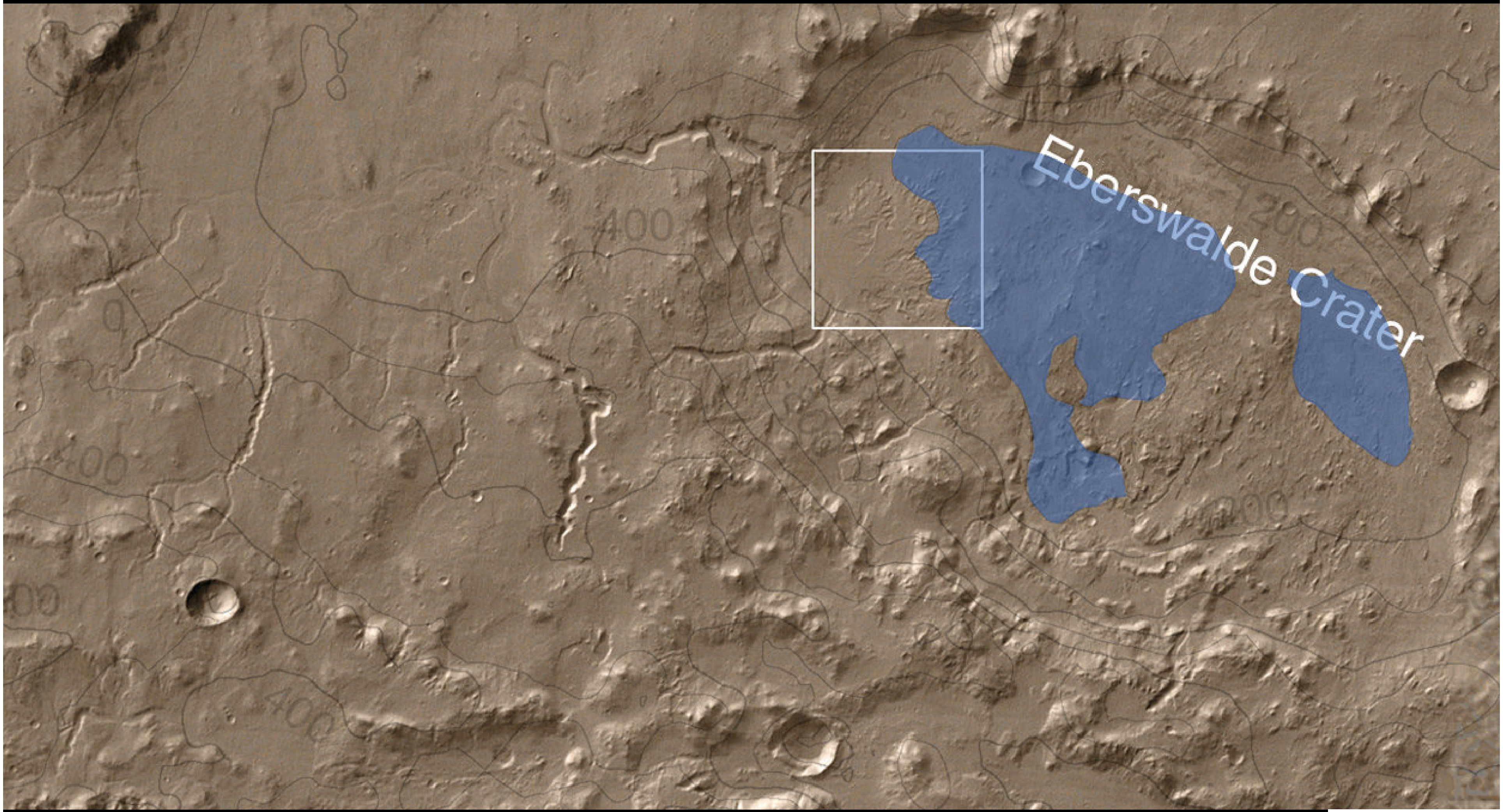


3 km
D = 12 km



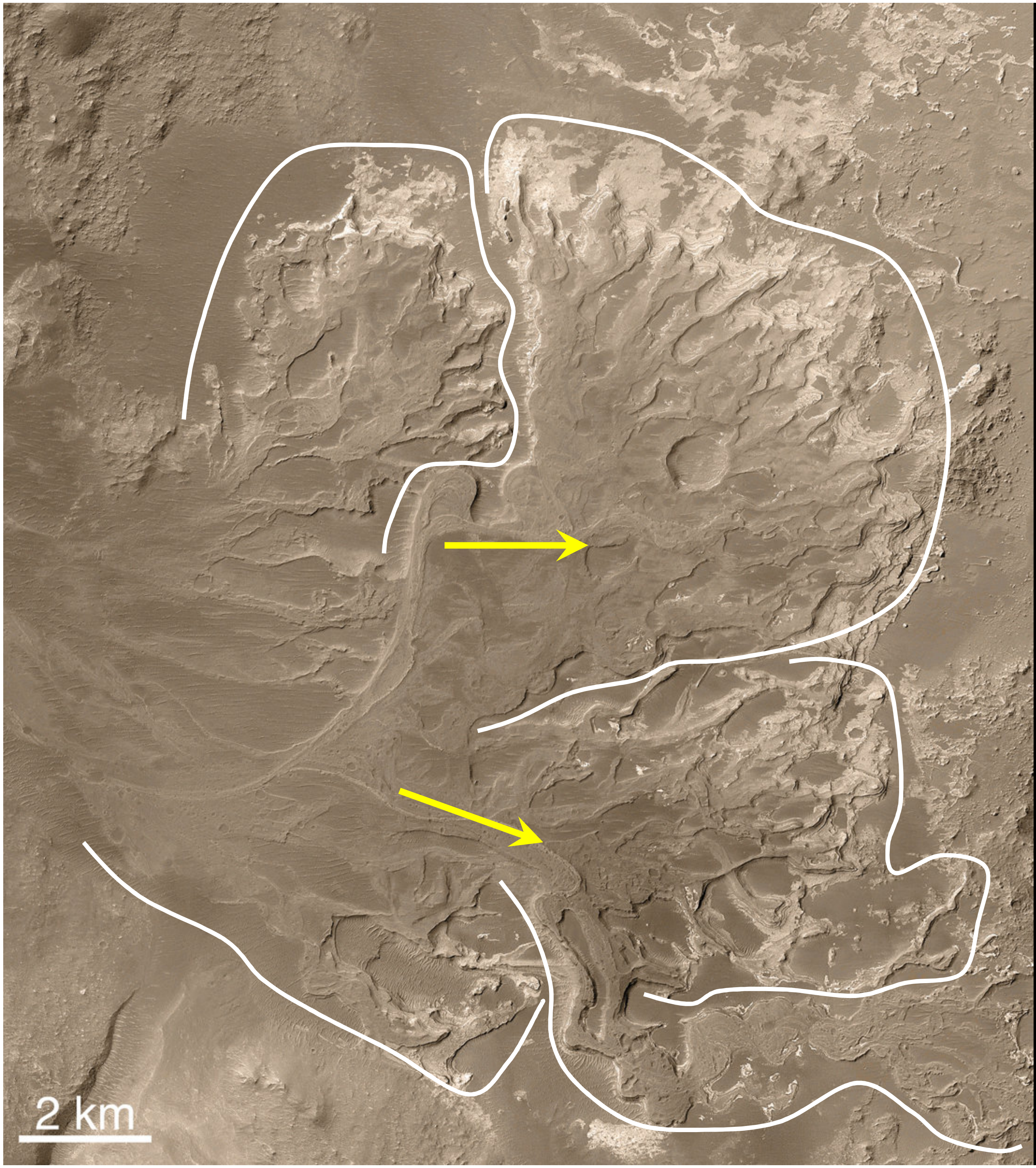
D = 7 km
3 km


20 km



Mosaic: Malin Space Science Systems (lake shade added)

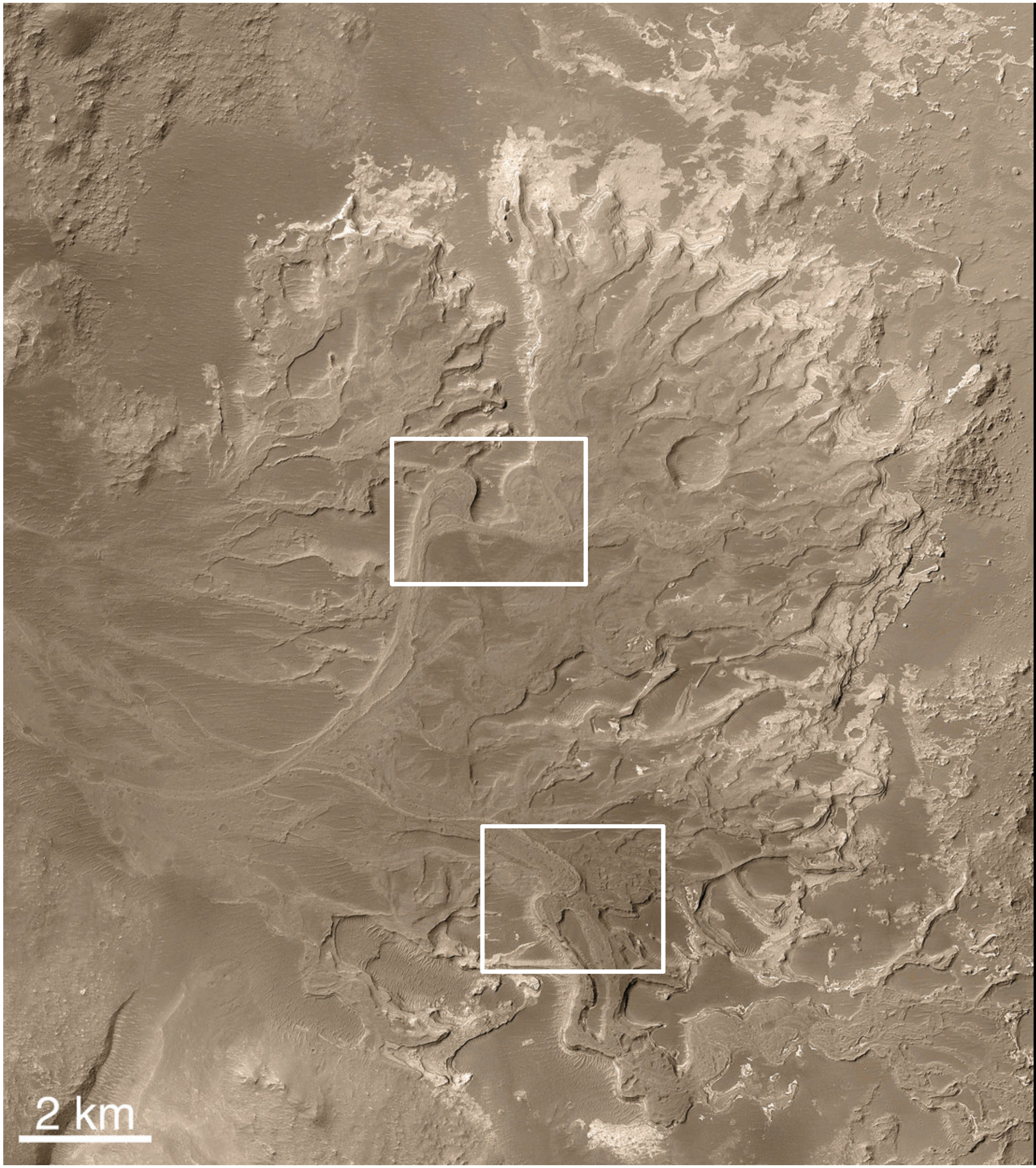
10 km



Major Lobes

Late transportive paleochannels

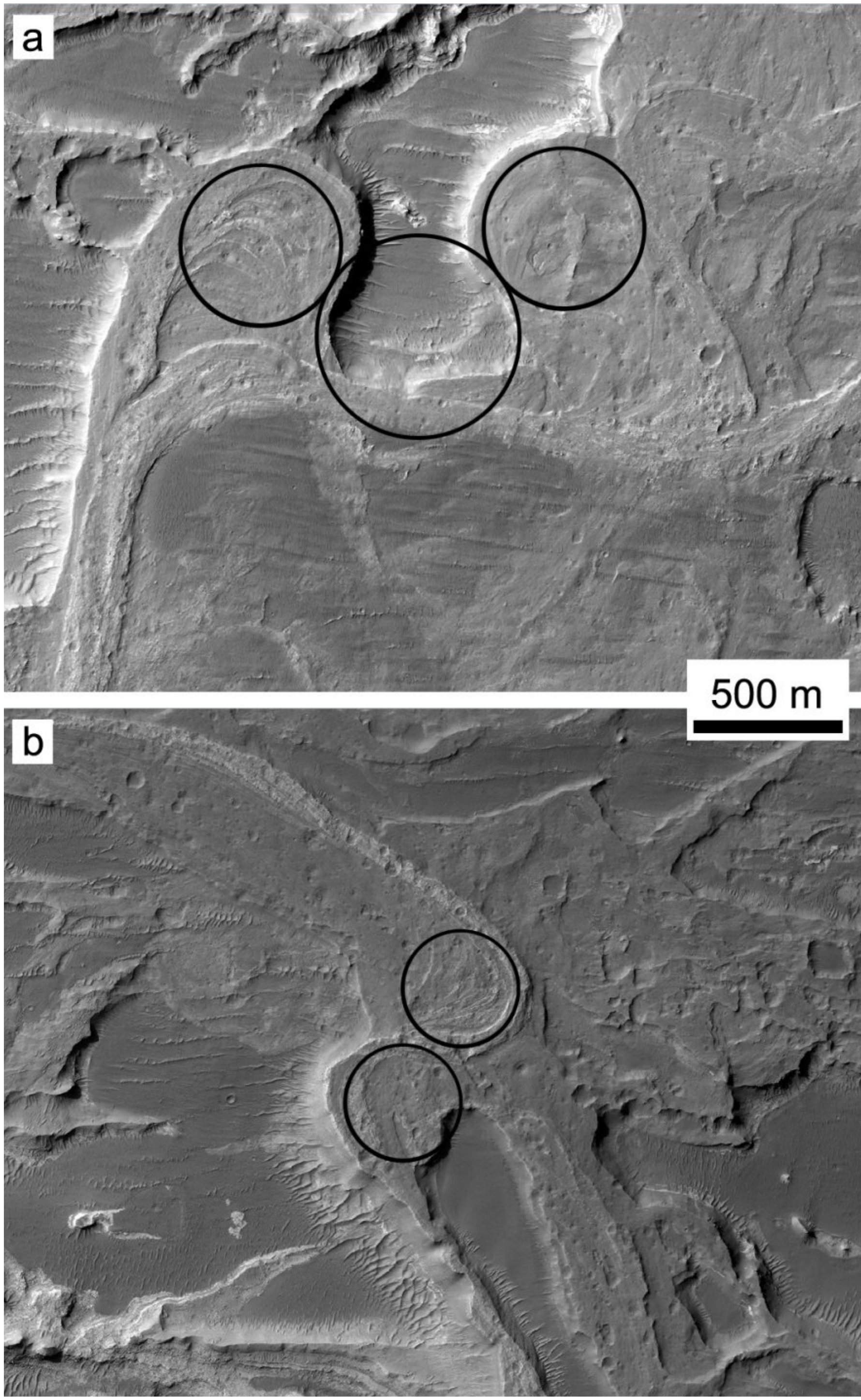
Mosaic:
Malin Space
Science Systems



MEANDERS

Mosaic:
Malin Space
Science Systems

MEANDERS



Songhua River, China (Google)

Eberswalde Crater Paleohydrology

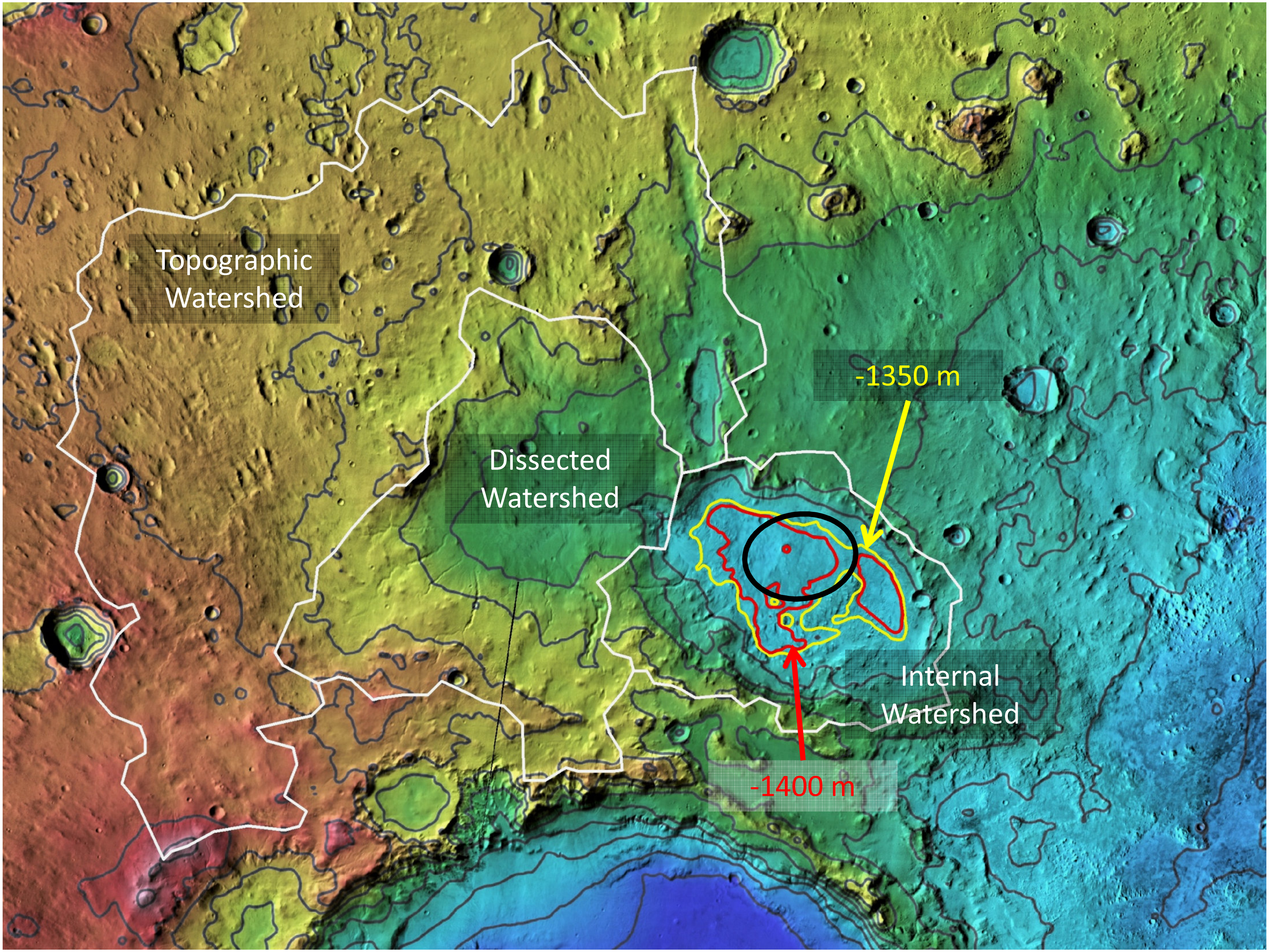
Eberswalde meander dimensions (m)

Paleo-channel	Width (mean of 5) W_b	Wavelength λ_m	Arc distance (mean of 2) λ_a	Belt width B	Radius of curvature (mean of 3) R_c
North	130	1240	1140	1000	260
South	50	740	530	420	170

Measured and expected channel width based on meander dimensions (m)

Paleo-channel	Measured width (mean of 5)	Width, from wavelength	Width, from arc distance	Width, from belt width	Width, from radius of curvature
North	130	100	120	130	100
South	50	60	60	60	70

$W_b = 0.17\lambda_m^{0.89}$ $W_b = 0.23\lambda_a^{0.89}$ $W_b = 0.27B^{0.89}$ $W_b = 0.71R_c^{0.89}$ (*Williams*, 1986)



Topographic
Watershed
Dissected
Watershed
-1350 m
Internal
Watershed
-1400 m

Eberswalde Crater Paleohydrology

Width-wavelength relationships in two inverted paleochannels

Consistent with meandering rivers on Earth

Inverted channels are well-preserved here

Bank-full flow for inverted paleochannels

From width: 450 m^3/s (north), 140 m^3/s (south)

From wavelength: 400 m^3/s (north), 180 m^3/s (south)

Annual runoff (lake levels of –1350 and –1400 m, 5,000 km^2 watershed)

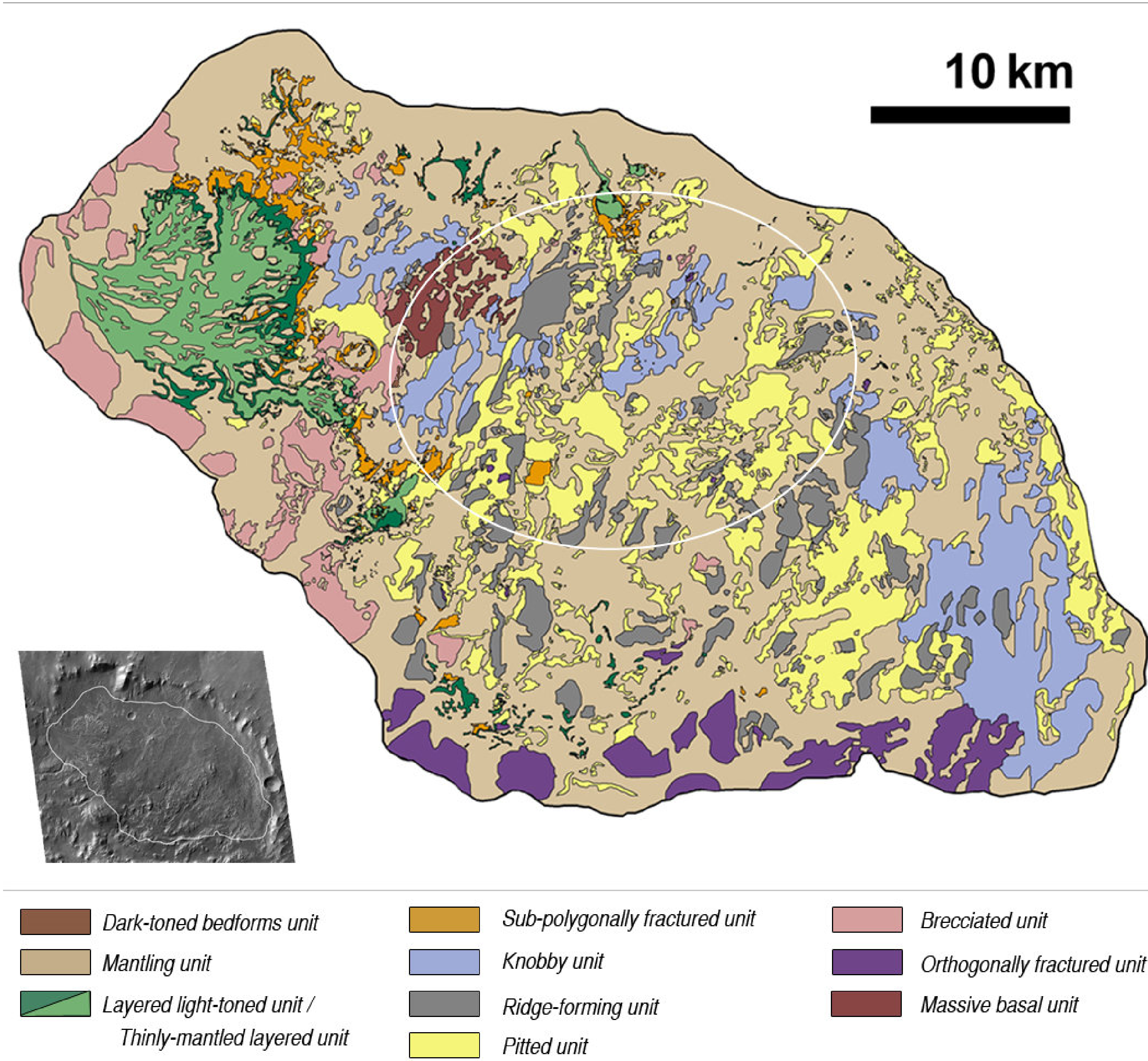
For evaporation of 1 m/y: 8–16 cm/y

For evaporation of 0.1 m/y: 0.8–1.6 cm/y

Deposition timescale (deposit volume of 6 km^3)

For water/sediment volume ratio of 1,000: tens to hundreds of thousands of years

For water/sediment volume ratio of 10,000: hundreds of thousands to millions of yrs

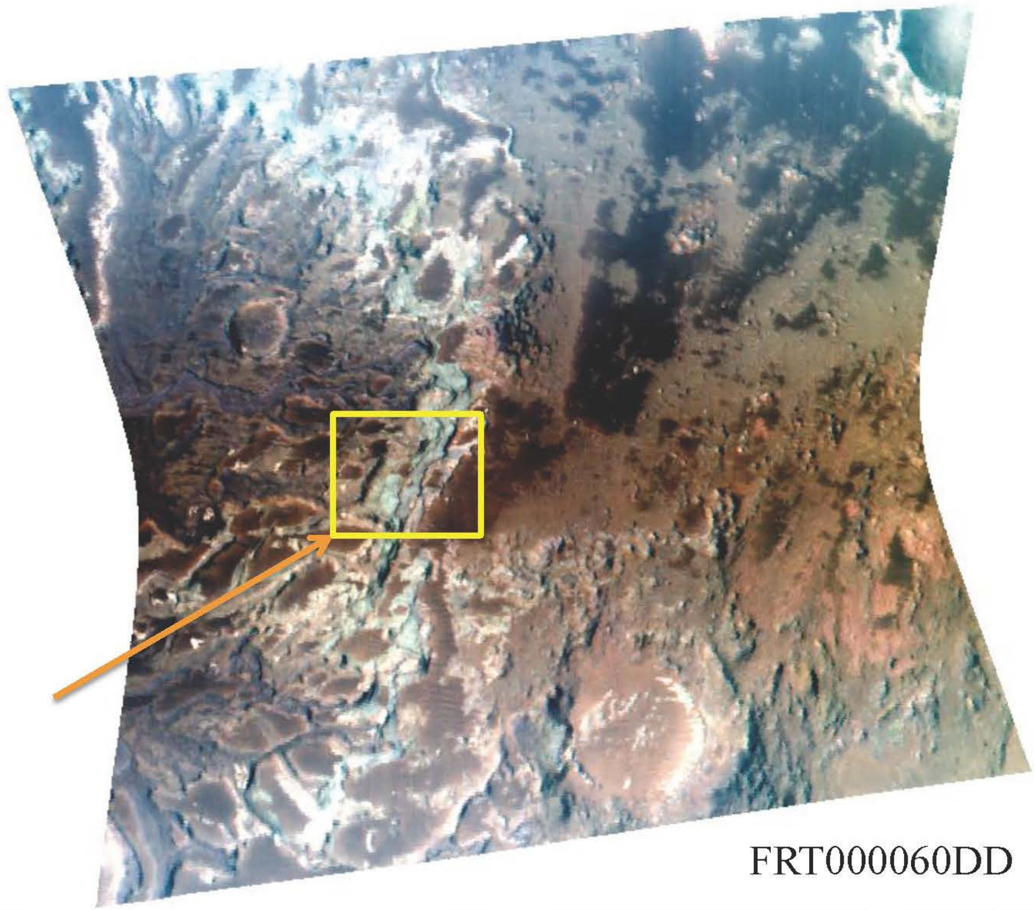


Rice et al. (2013)

West of ellipse

Light-toned layers within/near delta

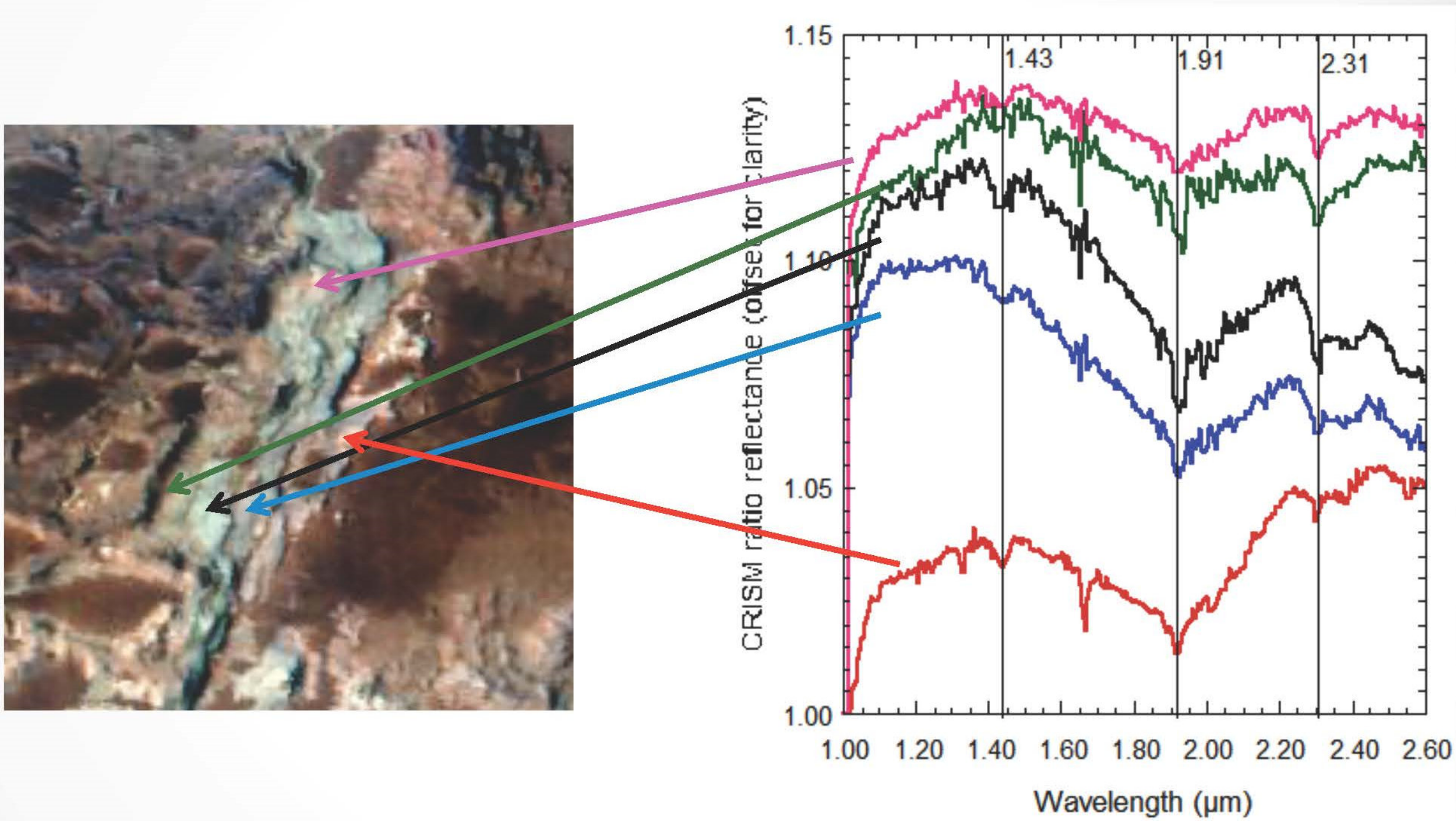
- Have clear Fe/Mg phyllosilicate signatures



FRT000060DD

McKeown and Rice (2011)

Delta layer mineralogy



McKeown and Rice (2011)

Eberswalde Crater Site

23.9S, 327E

Overarching Hypothesis:

- Eberswalde crater stratigraphy, geomorphology, and mineralogy record the evolution of a crater lake, the history of hydrologic and climatic changes resulting in the formation of fluvial-deltaic systems, and a sedimentary depositional environment that might have been favorable to the preservation of organic materials and/or other kinds of biosignatures.

Possible Cons of Site:

•Relatively limited variety and modeled abundance of phyllosilicate minerals known to preserve organics detected from orbit.

•Science in landing ellipse is secondary to that outside of the ellipse.

Specific Pros of Site:

Setting -

•Eberswalde shows excellent preservation of a fluvial-deltaic system emplaced into a standing body of water that integrates sedimentary material from a broad source region. Additional, smaller fluvial-deltaic systems and possible lacustrine deposits are also present.

•The landing site provides the opportunity to reconstruct quantitatively the sedimentary, hydrologic, and climate conditions during deposition. Specific formation models allow prediction of locations to target for exploration with MSL. Bottom set beds from each lobe of the delta can be defined and provide targets in which to seek organics.

•Evidence for episodic channel-meandering migration is recorded in the delta and associated estimates of discharge suggest its deposition extended for several hundred thousand years or more based on terrestrial analogs.

Diversity -

•In addition to fluvio-lacustrine deposits (e.g., sinuous ridges), Holden crater ejecta and possible megabreccia related to the Eberswalde impact event occur. Some megabreccia may express veins related to hydrothermal activity. The materials in the ellipse and delta include clay minerals whose distribution is associated with different outcrop characteristics.

Preservation -

•Orbital detection of clay minerals near the bottom of the delta front, maybe in bottom set deposits, define a well-defined target for exploration. There are also potential lake deposits within the landing ellipse that offer exploration targets. On Earth, such deposits can concentrate and preserve organics and evidence for habitability and life.

Exploration Targets –

•Well-defined fluvial-deltaic-lacustrine and megabreccia targets coupled with mineralogical diversity within and outside of the ellipse defines a short and long term exploration strategy. Lacustrine sediments likely exposed in and near the ellipse and distribution is becoming well-mapped. Distribution of targets make exploration of the site a mix of land on and go to.

Remaining Uncertainties:

• Little evidence for shorelines corresponding to the elevation of the delta surface and the spillway to the eastern basin, though some aspects of the system (including the poorly defined shorelines) suggest it may have been ice-covered (though no deformation of delta as might be expected if it was). Predictions made enable this to be evaluated in situ.

• Delta emplacement might be consistent with delivery of water and sediment shortly after the Holden impact; this cannot be ruled out in advance of landing, but tests are proposed to resolve in situ. Sediment contributions to the delta from Holden ejecta are uncertain though mapping of tributaries and characteristics of incision will help resolve in advance of landing.

• Delta is no older than Early Hesperian and some investigators believe it may have been deposited as late as the Early Amazonian, but there is no consensus whether a post-Noachian age is of a concern for preserving organics or for preserving evidence for past habitability or life on Mars.

CONCLUSIONS, 1 OF 2

- Eberswalde postdates Holden basin (MN), predates Holden crater (H)
- Muting of relief continued after Holden impact
- Fresh craters formed on Holden rim & secondaries, later dissection
- Eberswalde delta northwest lobe formed first, then eastern lobes
- If it's an alluvial fan, then it's not due to the Holden impact
- Late transition from distributive to transportive planform
- Meandering possibly enabled by cementation
- Paleochannel width consistent with meander geometry
- Dominant discharge about 400 and 200 m^3/s in two late paleochannels
- Event runoff production up to 1 cm/day
- Annual runoff production (intermittent) about 1-20 cm/year
- Annual snowmelt or infrequent moderate rainfall are possible
- Deposition timescale 10^4-10^6 years for water/sed volume of 1,000 – 10,000
- Abundant outcrops in MSL ellipse, almost all under water

CONCLUSIONS, 2 OF 2

- Very short deposition time scales are implausible
- Can concentrate, preserve, and exhume organics (if present)
- Diverse materials in Holden ejecta, but not in place
- Date the Holden impact?
- Site thoroughly mapped and vetted for MSL
- Low elevation provides margin
- REFS: Malin and Edgett (2003), Moore et al. (2003), Jerolmack et al. (2004), Bhattacharya et al. (2005), Lewis and Aharonson (2006), Wood (2006), Pondrelli et al. (2008, 2011), Rice et al. (2011, 2013), Mangold et al. (2012), papers by J. Grant and T. Parker